AD-777 022

RADIO CONTROLLED IR INDICATOR LIGHT FOR MILITARY DOGS

John W. Woestman

Franklin Institute Research Laboratories

Prepared for:

Army Land Warfare Laboratory

December 1973

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER LWL-CR-04B72	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD 777022
4. TITLE (and Subtitle) Radio Controlled IR Indicator Light for Military Dogs		5. TYPE OF REPORT & PERIOD COVERED Final Report October - December 1973
		6. PERFORMING ORG. REPORT NUMBER F-3538-06
7. AUTHOR(s) John W. Woestman		8. CONTRACT OR GRANT NUMBER(s) Contract No. DAAD05-73-C-0145
9. PERFORMING ORGANIZATION NAME AND ADDRESS The Franklin Institute Research Laboratories Benjamin Franklin Parkway Philadelphia, PA 19103		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS LWL Task 04-B-72
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Land Warfare Laboratory Aberdeen Proving Ground, MD 21005		12. REPORT DATE December 1973
		13. NUMBER OF PAGES 45
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Radio controlled IR light for dogs
Visualization of dogs at night
Illumination of working dogs at night
IR illumination of dogs
Night visualization of dogs
Remote controlled IR light

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A radio controlled IR light mounted on a dog harness was developed to enable a military dog handler to visualize, with the aid of an appropriate IR viewing device, the location of his dog at night. The system consists of a hand-held radio transmitter and the dog-mounted receiver unit with a pulsed IR light source.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

 UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

FOREWORD

This report is submitted in compliance with contractual requirements as directed by the U.S. Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland, under Contract DAAD05-73-C-0146.

Principal Investigator for the program at The Franklin Institute Research Laboratories was Mr. J. Woestman, Staff Engineer, Electrical Engineering Department.

CONTENTS

Preceding page blank

FIGURES

1. INTRODUCTION

One of the requirements for utilizing military dogs off-leash at night is that the handler must be able to see or visually locate his dog. Field evaluation of a night viewing system developed for this purpose showed that night vision binoculars alone are adequate for viewing dogs at night to a distance of about 50 meters, but that a supplementary radio-controlled IR light source on the dog would be of great assistance to enable the viewer to locate the dog if it becomes momentarily obscured in vegetation and underbrush. This program was undertaken to provide a simple lightweight system that could provide such an IR light and a controlling transmitter for field evaluation.

2. SYSTEM DESCRIPTION

The radio controlled system consists of a hand held radio transmitter and a companion radio receiver together with a pulsed IR light and battery power supplies. A block diagram of the entire system is shown in condensed form in Figure 2-1. The transmitter is contained in a single unit including its battery power supply. The receiving system is contained in two units. Figures 2-2 and 2-3 are photographs of the complete system.

2.1 Transmitter Unit

The transmitter unit consists of a Heathkit Model GDA-1057-1 Proportional Radio Control Transmitter modified so as to activate the receiver decoder in Channel 3 only. The unit is 3 3/4 x 2 9/16 x 10 inches overall and weighs 2.0 pounds. The antenna telescopes into the case when the equipment is not in use. A hand strap on the back of the unit enables one-hand operations.

Input power to the RF power amplifier is approximately 500 milliwatts. Coding is by pulse interruption of the carrier. The unit has been wired so that it is necessary to place the power switch in the on position to put the transmitter in a standby condition. Pressing the push-button then activates the transmitter. The transmitter is continuously coded until the push-button is released. RF output occurs only so long as the push-button is depressed. Operating frequency is 27.195 Mhz, which is one of the radio control channels in the Citizens Radio Band.

2.2 Receiving System

The receiving system is built around a Heathkit Model GDA-1057-2 Proportional Radio Control Receiver modified so that only the third channel output is utilized. The receiver output is fed into a lamp energizing circuit which in turn switches battery power to the four grain-of-wheat lamps mounted in the lamp assembly. Both the receiver

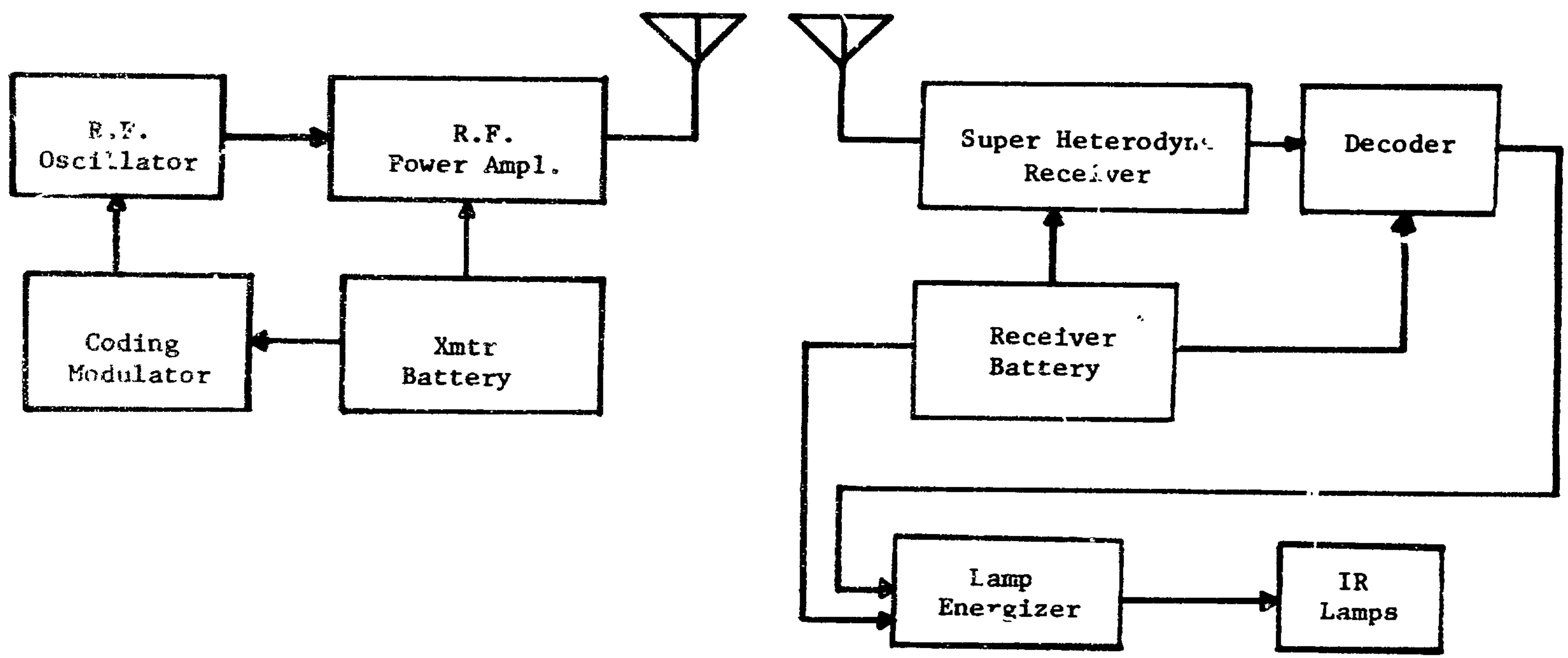


Figure 2-1. Radio Controlled IR Indicator Light

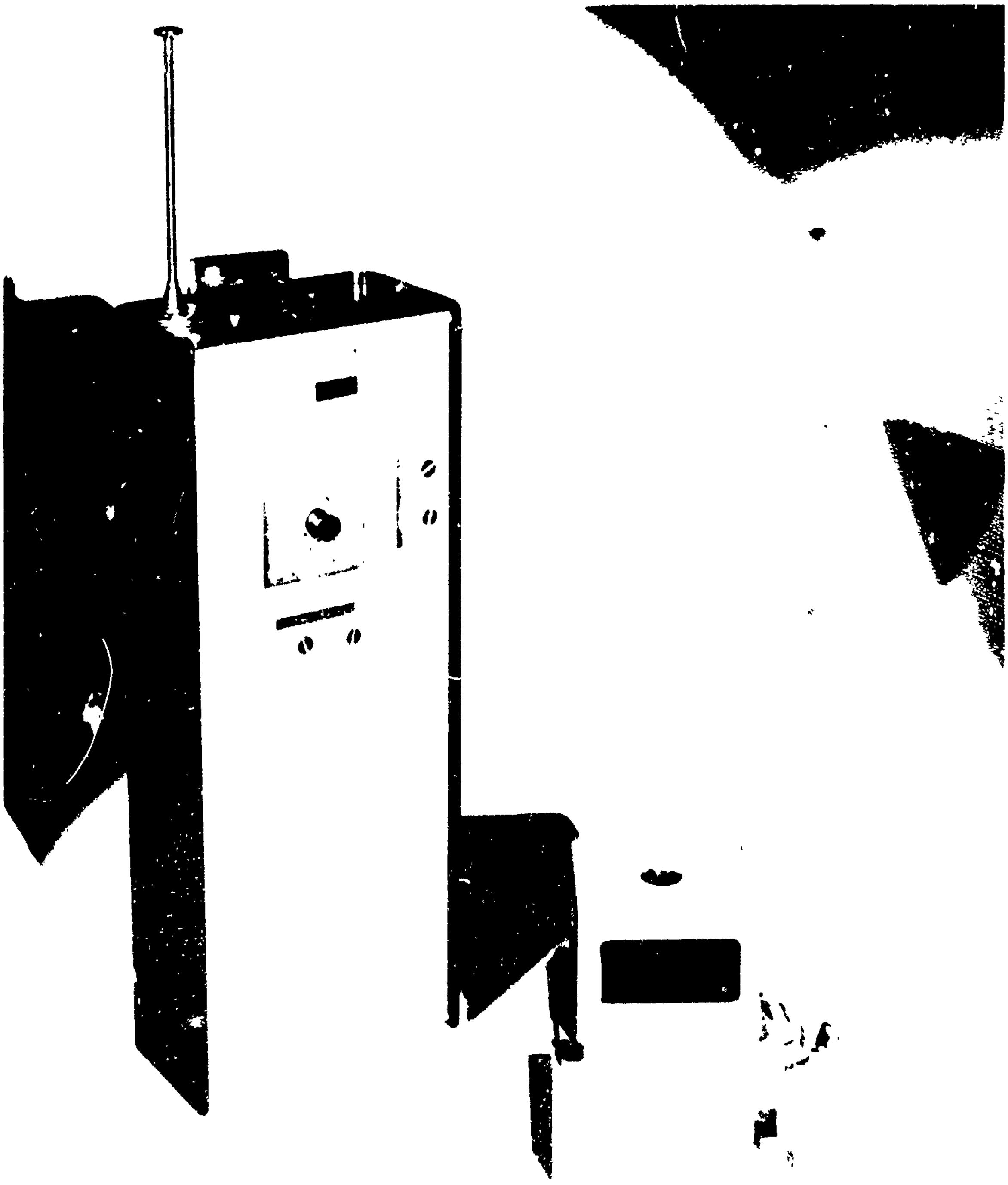


Figure 2-2. Transmitter (left) and Receiving System (right)

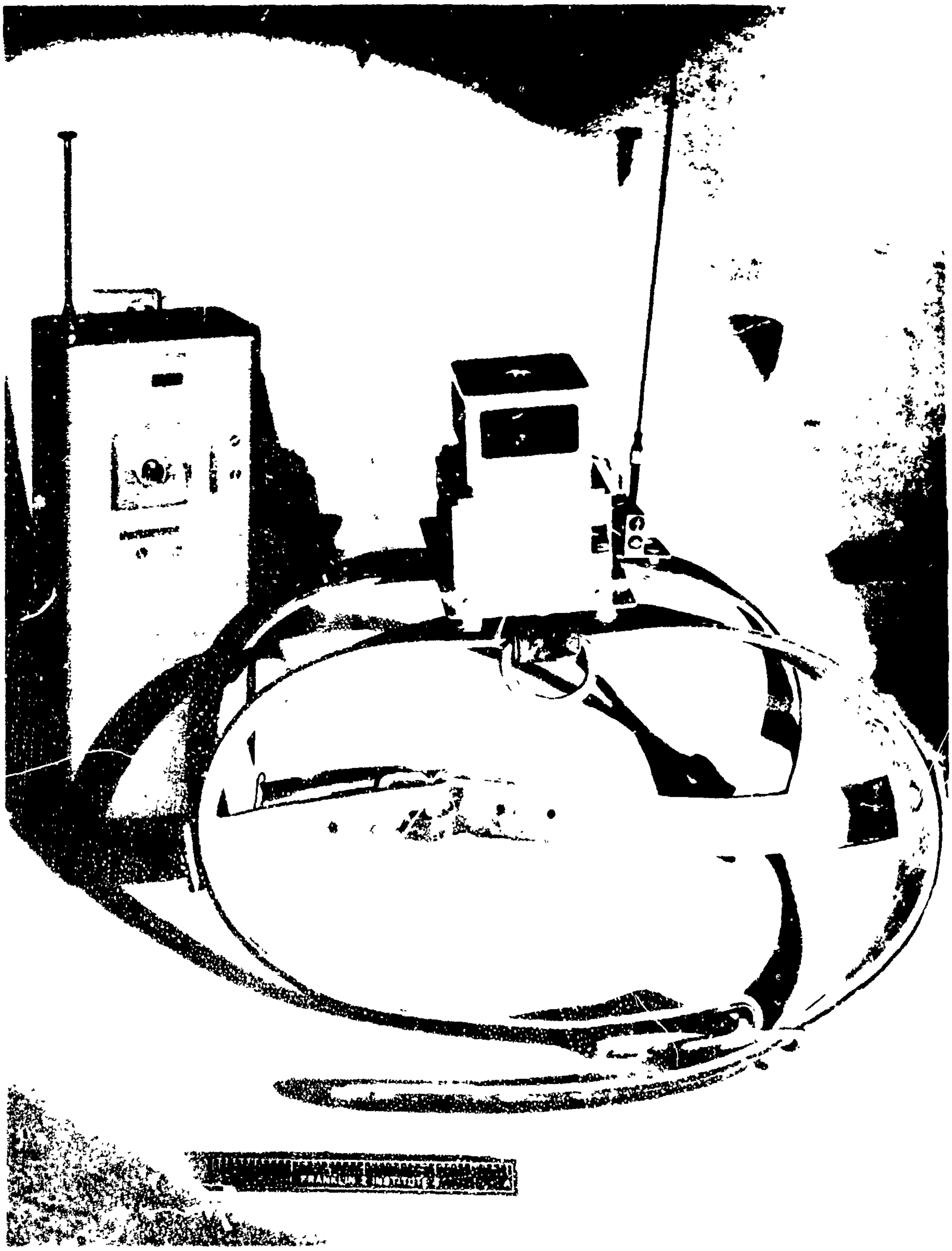


Figure 2-3. Complete System. Transmitter at left; Receiving System mounted on dog harness (right).

and the lamps are powered by the receiver battery supply.

The receiving system is mounted in two stacked aluminum housings and weighs 26 ounces. The receiving antenna is an eighteen-inch whip antenna military type AS1998A/PRR9. The receiver remains on as long as the power switch is on. The lamps are energized only so long as the proper code is being received from the transmitter. Figures 2-4, 2-5 and 2-6 are photographs of the receiving system. In Figure 2-5, the components which make up the receiving system are shown.

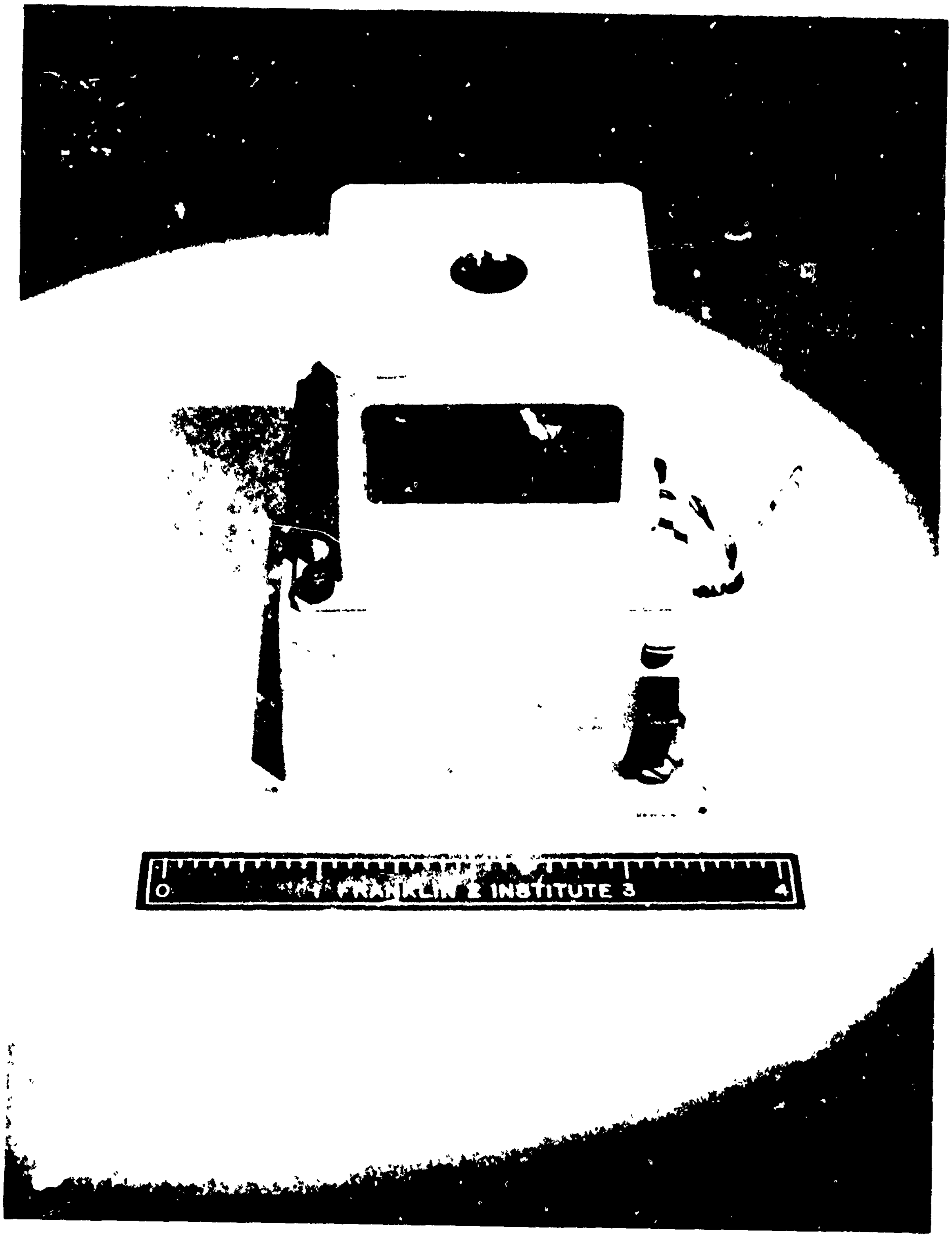


Figure 2-4. Receiving System, unmounted and without antenna

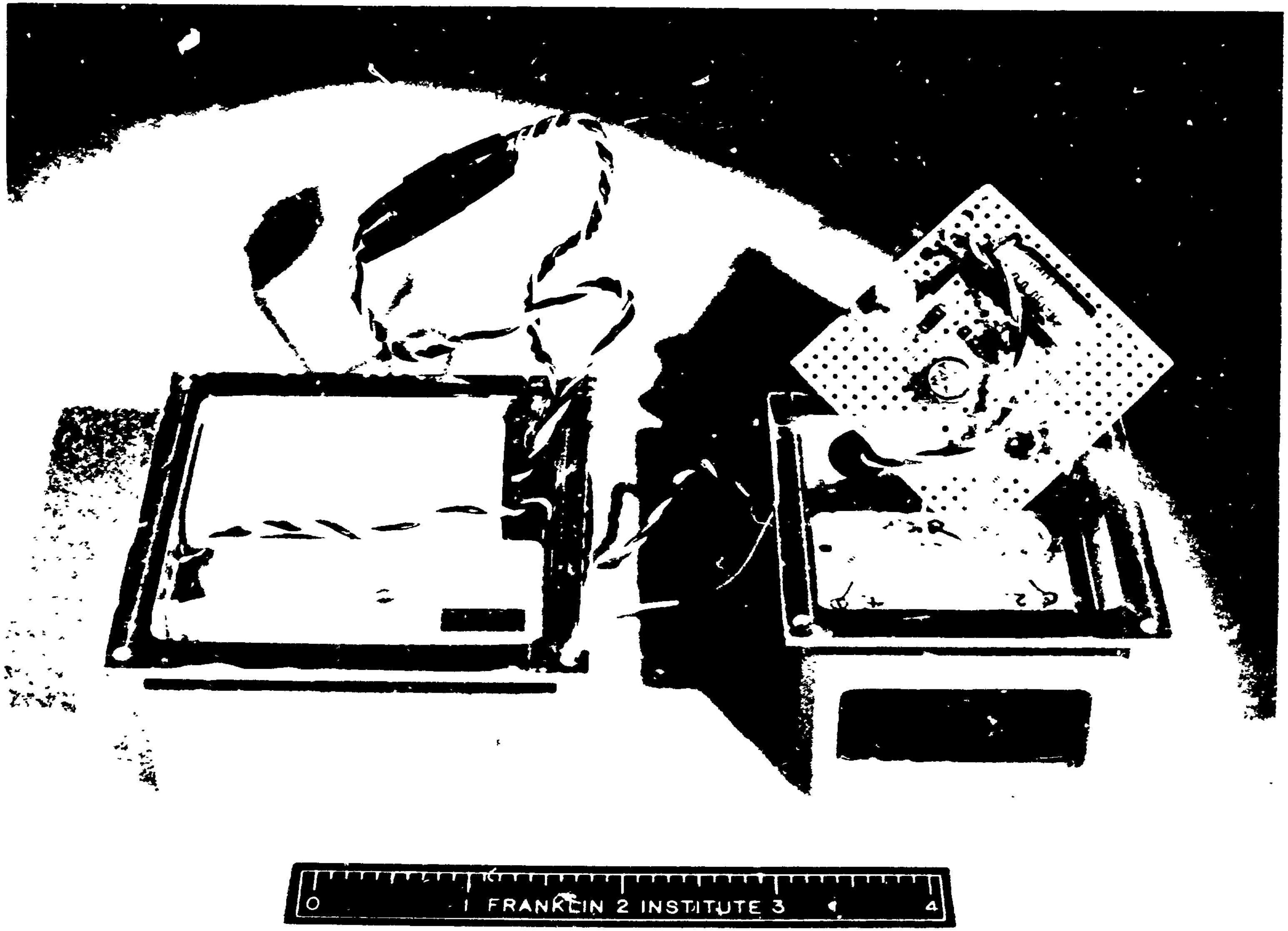


Figure 2-5. Receiving System. 27 Mhz receiver (lower left), battery pack (upper left) and light assembly (right) exposing lamp driver circuit board.

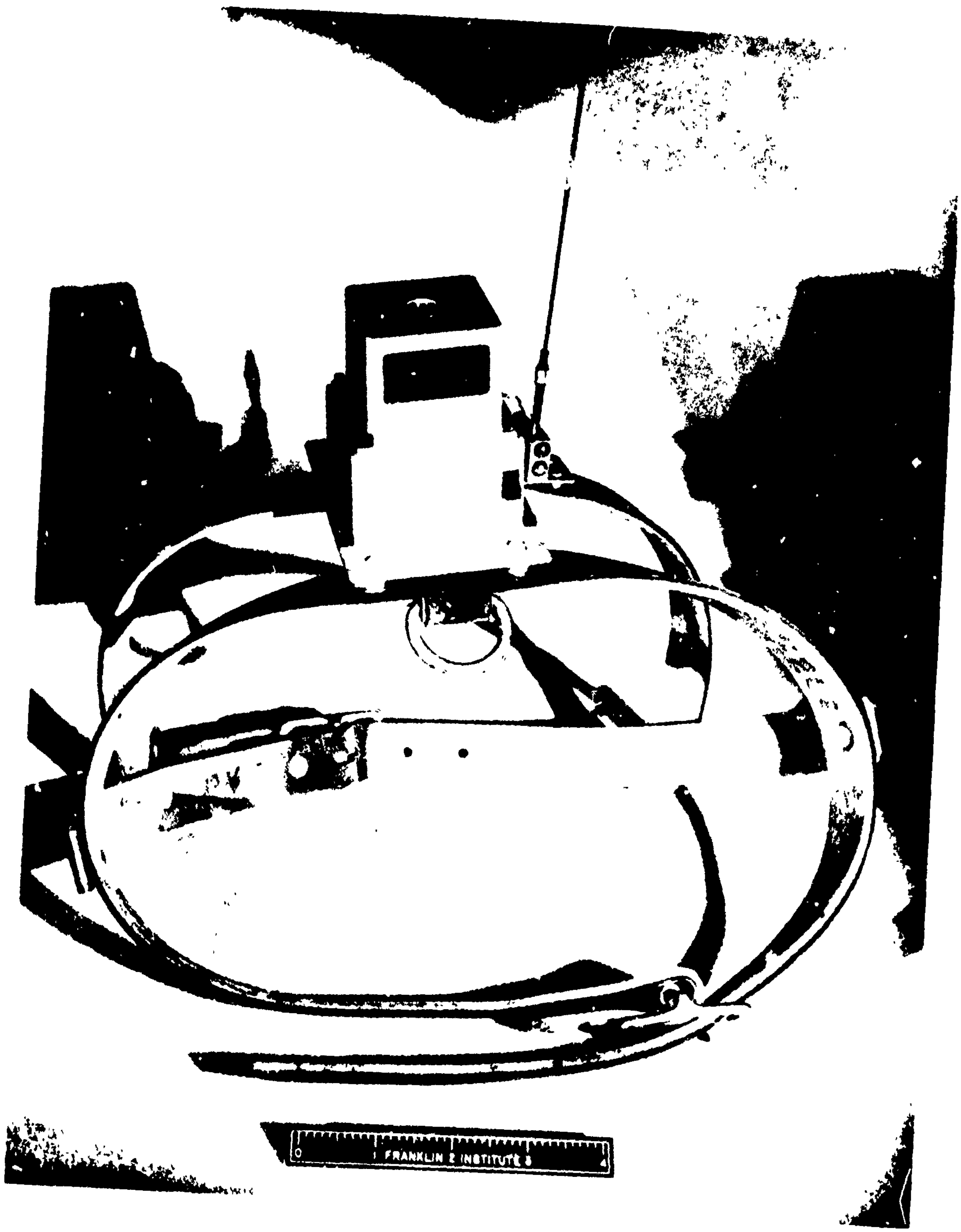


Figure 2-6. Receiving System, complete and mounted on dog harness

3. THEORY OF OPERATION

The basic system consists of a continuous radio frequency carrier which is interrupted at a 62.5 Hz rate for intervals of 350 microseconds. The system has been modified so that the normal 3 channels are activated but only the third channel controls the IR lights. The system sequences through the channels number 1, 2 and 3 after reception of an initiating sync pulse. The third channel was utilized to activate the IR lights as a means of enhancing system noise immunity and security. A detailed explanation of the operation of the circuit follows.

3.1 Transmitter Circuit

The complete schematic of the modified transmitter circuit is given in Figure 3-1. The pulse modulation applied to the carrier is shown in Figure 3-2. Waveform A in Figure 3-2 shows a frame of five pulses that is repeated every 16,000 microseconds in a continuous train. Each pulse in the frame is 350 microseconds wide, and all pulses in a frame except the first one normally start 1500 microseconds after the start of the previous pulse.

The time interval between the first pulse in one frame and the first pulse in the next frame is always 16,000 microseconds. This is called "fixed frame rate."

The long space between the last pulse in a frame and the first pulse in the next frame is called the sync pause. This locks the receiver's decoder circuit in synchronization with the transmitted signal. When one of the channel controls is moved, that channel's time interval is changed. Waveform B of Figure 3-2 shows the relative position of the pulses when the Channel #2 control is moved to increase its time interval. The other channels are not affected, although the sync pulse time is shortened by the amount of channel 2 increase.

The frame waveform modulates the RF carrier as shown in Figure 3-3. That is, the carrier is turned off during the 350 microsecond pulses, but

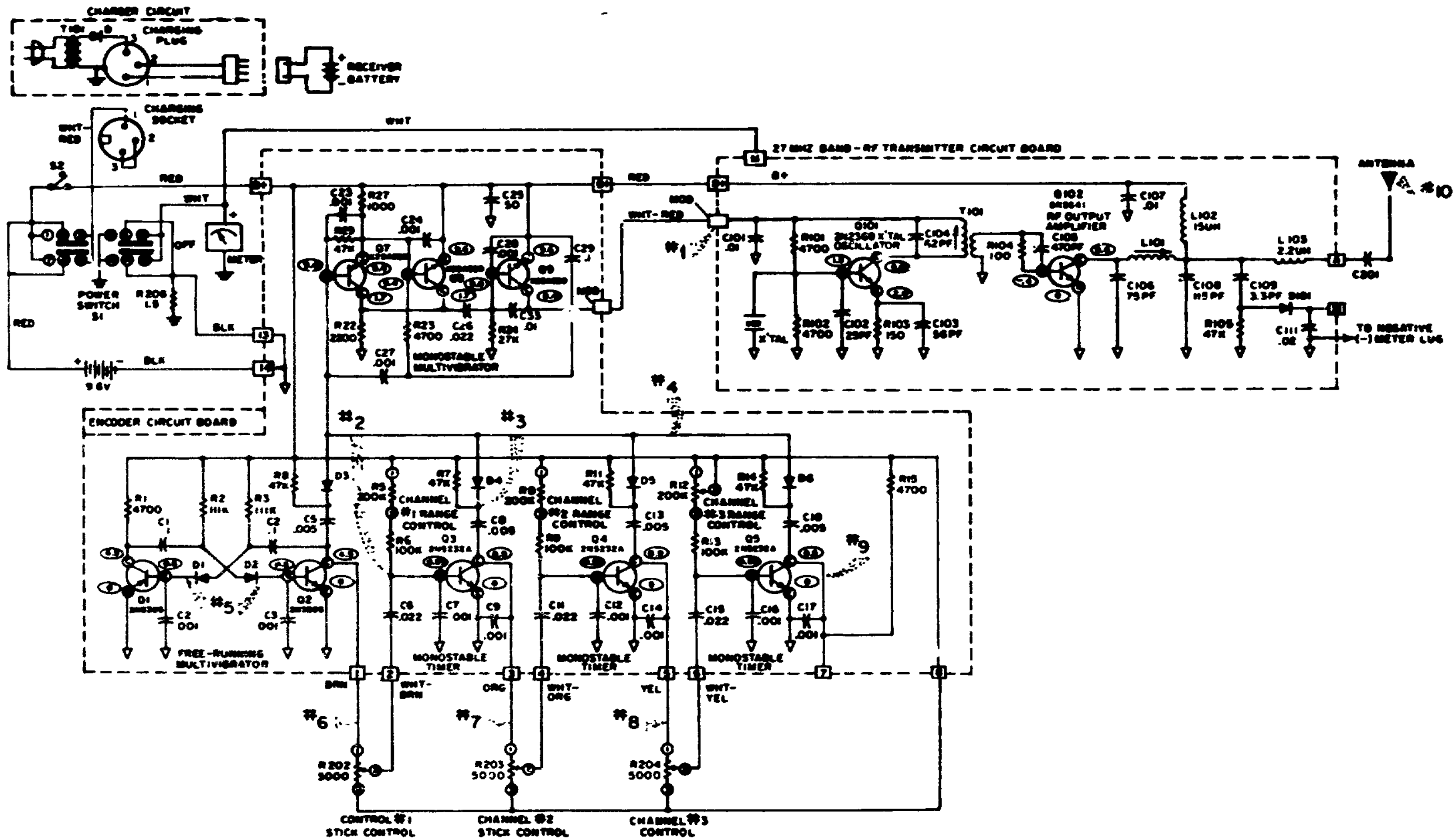


Figure 3-1. Modified Transmitter Circuit

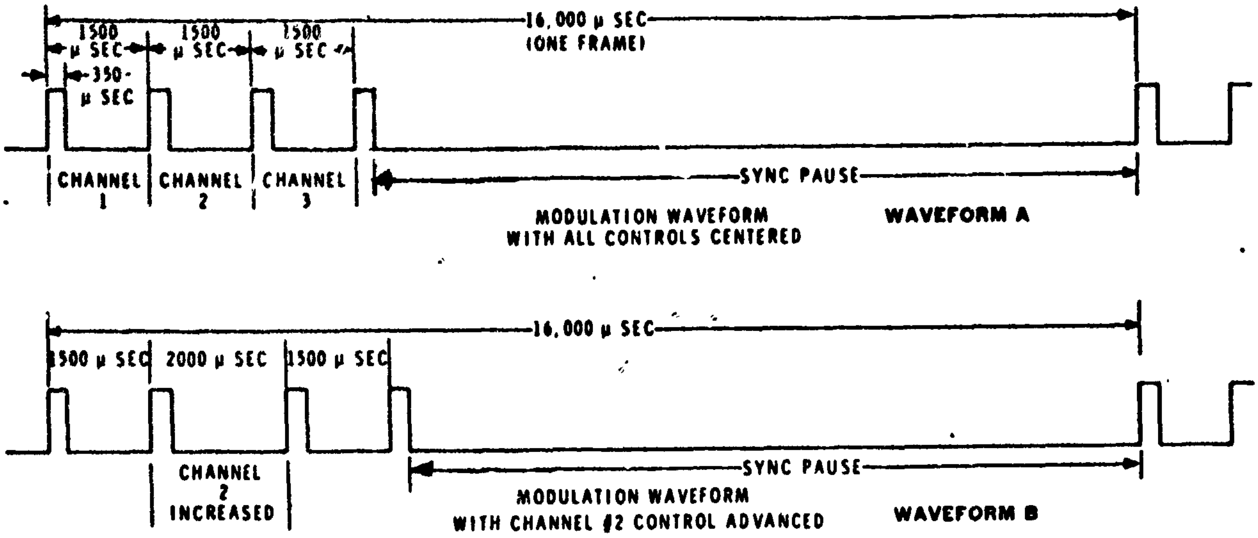


Figure 3-2. Frame of 5 Pulses (Waveforms A and B)

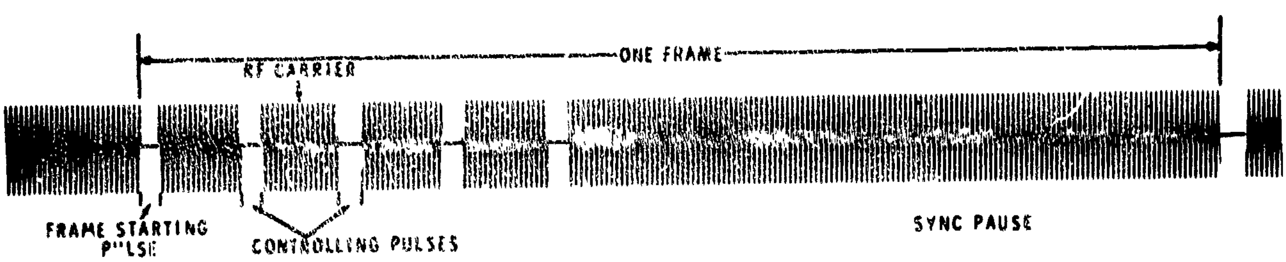


Figure 3-3. Modulated RF Carrier

is on at all other times. This form of modulation reduces the possibility of the Receiver circuits being triggered by interference, which would cause the lamp energizing circuit to operate erratically.

A number series has been assigned to each of the two circuit boards and to the cabinet in the Transmitter. These number series are used on the Schematic Diagram and in this Circuit Description to identify and locate circuits and parts. The part numbers are grouped as follows:

1-99 Parts mounted on the encoder circuit board.
101-199 Parts mounted on the RF transmitter circuit board.
201-299 Parts mounted on the cabinet.
300-399 Parts mounted in charger.

Pulses that are used to modulate the RF carrier of the Transmitter originate in the circuits of the encoder circuit board. These circuits include a free-running multivibrator, four monostable timers, and a monostable multivibrator. The RF circuit board contains a crystal-controlled oscillator and an RF output on the 27 MHz band.

3.1.1 FREE-RUNNING MULTIVIBRATOR

Transistors Q1 and Q2 are connected in a circuit that operates as a free-running multivibrator. Alternately, one of these tranistors conducts while the other is cut off.

Assume that transistor Q1 conducts first when power is applied to the circuit. The voltage at the collector of Q1 is reduced, causing capacitor C1 to start charging through resistor R2 from the power supply. During the charging of C1, the voltage to the base of Q2 increases sufficiently to cause Q2 to conduct, reducing its collector voltage to near zero. This applies a negative voltage through C4 to the base of Q1 and stops Q1 from conducting. Now C4 begins to charge through R3. During the charging of C4, the voltage to the base of Q1 rises in a positive direction and Q1 again conducts.

The time required to charge C1 through R2, and C4 through R3, determines the period of the multivibrator. The values of these resistors and

capacitors are chosen to turn each transistor on and off every 16,000 microseconds. This multivibrator period of 16,000 microseconds produces the starting pulse for each frame and this frame starting pulse is coupled through capacitor C5 and diode D3 to transistor Q7 of the monostable multivibrator circuit. The pulse also passes through Channel #1 Control R202 to a series of monostable timers which produces the other three pulses for channel information and will be described next.

3.1.2 MONOSTABLE TIMERS

Transistor Q3 through Q5 are connected in three identical monostable timer circuits. Each frame-starting Pulse from the free-running multivibrator begins a chain reaction through the monostable timers. Since these circuits are identical, only the operation of Q3 will be described.

Transistor Q3 is biased through Channel #1 Range control R5 and resistor R6 so that it is normally conducting and its collector voltage is near zero. The negative frame-starting pulse from transistor Q2 is coupled from the arm of control R202 through capacitor C6, to the base of Q3. This pulse drives the base of Q3 negative by an amount that depends on the setting of R202, cutting off the transistor.

As soon as the negative frame-starting pulse is fed to the base of Q3, the voltage at this base begins to rise again due to positive voltage through R5 and R6. When the base reaches +.6 volts, Q3 again conducts. The time required for the base to reach +.6 volts is affected by the time constant of R5, R6, and C6, as well as by the amplitude of the pulse that is passed through control R202. Thus, control R202 provides manual control of the pulse amplitude, which controls the length of time that transistor Q3 is cut off.

Control R5 adjusts the effective range of control R202 by altering the charging time of capacitor C6. (Note: The charge curve of C6 is the trailing edge of the pulse at the base of Q3.) As C6 charges up to +.6 volts more slowly, for example, due to a larger resistance value of R5, a wider range of pulse widths is available from the collector of Q3. When the resistance of R5 is decreased, a smaller range of pulse widths

is available from Q3.

When transistor Q3 again conducts, a negative-going pulse appears at its collector. This pulse is passed through Channel #2 Control R203 to the next monostable timer circuit which operates in the same manner as the circuit of Q3. Note that only the negative-going portion of the pulse will trigger this stage.

The channel #1 controlling pulse from Q3 is coupled through C8 and D4 to the monostable multivibrator circuit Q7, Q8, and Q9. Diodes D5, D6, and D7 couple the other controlling pulses to the monostable multivibrator.

3.1.3 MONOSTABLE MULTIVIBRATOR

Transistors Q7, Q8, and Q9 are connected to operate as a monostable 350 microsecond multivibrator. Its purpose is to cause each frame-starting pulse and controlling pulse to modulate the transmitter's RF carrier for only 350 microseconds during each pulse.

Diodes D3 through D7 allow only the negative-going portion of the pulse from the monostable timers and the multivibrator to be applied to the base of transistor Q7. Since the emitter of Q7 is direct coupled to the base of Q8, this negative-going pulse causes Q7 and Q8 to conduct and produce a positive pulse at the collector of Q8. This positive pulse is coupled through capacitor C26 to the base of Q9, causing Q9 to cut off. The time constant of C26 and R24 holds transistor Q9 cut off for a period of 350 microseconds after each pulse is applied to its base. Resistor R23 provides positive DC feedback from the collector of Q9 to the base of Q8. This feedback insures that Q8 continues to conduct during the 350 microsecond cutoff period of the monostable multivibrator.

From the collector of transistor Q9, power is supplied to the crystal circuit on the 27 MHz band. Since Q9 normally conducts, and is cut off during the presence of pulses, this transistor turns the crystal oscillator off and on like a switch and thereby modulates the RF signal.

3.1.4 27 Mhz BAND RF TRANSMITTER CIRCUITS

The crystal-controlled oscillator and RF output amplifier circuits are contained on the small RF Transmitter circuit board. These circuits generate and amplify the radio frequency carrier signal that is modulated by the controlling pulses from the multivibrator.

Crystal oscillator transistor Q101 operates as a grounded-base Colpitts oscillator. The primary winding of transformer T101, which is in parallel with capacitor C104, tunes the circuit to the frequency of the crystal.

During the intervals between pulses from the monostable multivibrator circuit, while transistor Q9 conducts, power is applied through the primary winding of T101 to the collector of Q101, causing the oscillator to operate. Since the oscillator stops when the power is cut off during a pulse, the oscillator's output signal is negative-modulated by the pulse signals.

The secondary winding of transformer T101 couples the modulates oscillator signal to the base of final RF amplifier transistor Q102 through capacitor C105. Q102 conducts on the positive peaks of the RF carrier which charges C105 to the polarity shown. R104 provides a return path for the negative voltage on the base of Q102 and provides proper bias. This bias is determined by the time constant of R104 and C105.

Transistor Q102 operates as a tuned collector amplifier. The pi network of C106, C108 and L101 tunes the amplifier output to the crystal frequency and provides a proper impedance match between Q102 and the antenna. Coil L103 is the antenna loading coil, and capacitor C201 prevents the DC supply voltage from reaching the antenna. B+ voltage is supplied through choke L102.

A portion of the RF signal is taken from the pi network through C109 and rectified by diode D101 to operate the meter, which indicates relative carrier strength. Resistor R105 provides a DC return path for the diode while capacitor C111 filters the diode's rectified output.

The pulse-modulated RF signal is radiated from the collapsible whip antenna to be received and detected by the Receiver. The modulation voltage is applied continuously to the transmitter whenever the transmitter power switch is on and the front panel push-button is depressed. If the push-button is depressed when the power switch is in the off-position, the transmitter is not activated. This provision prevents accidental transmission.

3.1.5 POWER SUPPLY

Power for the Transmitter circuits is supplied by a self-contained rechargeable, 9.6-volt, nickel-cadmium battery. When the Power switch is in the OFF position, the Battery is connected to an external charger which operates in the following manner.

The positive (+) end of the Receiver Battery is connected to the charging circuit through pins 2 and 3 of the charging socket. This socket is wired in such a way that the charging circuit must be connected to the transmitter <u>and</u> the receiver before it can work.

120-volt AC current from the charger line cord is transformed to low voltage AC by transformer T301 and rectified to low voltage DC by diode D301. This voltage is then used to charge the batteries.

Diode D301 rectifies the AC voltage, and resistor R206 acts as a shunt for the meter. The meter indicates when the batteries are being charged.

3.2 Receiver Circuit

The schematic diagram of the receiver and decoder circuits are shown in Figure 3-4. The schematic of the lamp driving circuit is given in Figure 3-5.

A number series has been assigned to each of the two circuit boards used in this Receiver. This number series is used on the Schematic Diagram to identify and locate circuits and parts. The part numbers are grouped as follows:

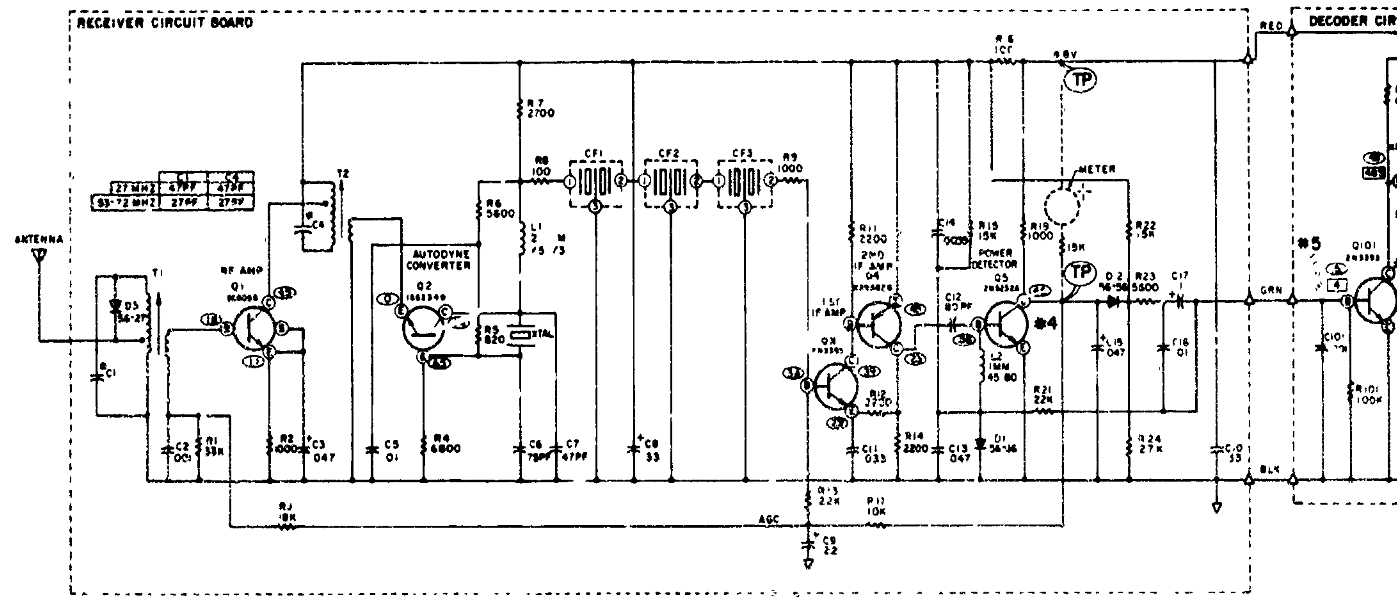
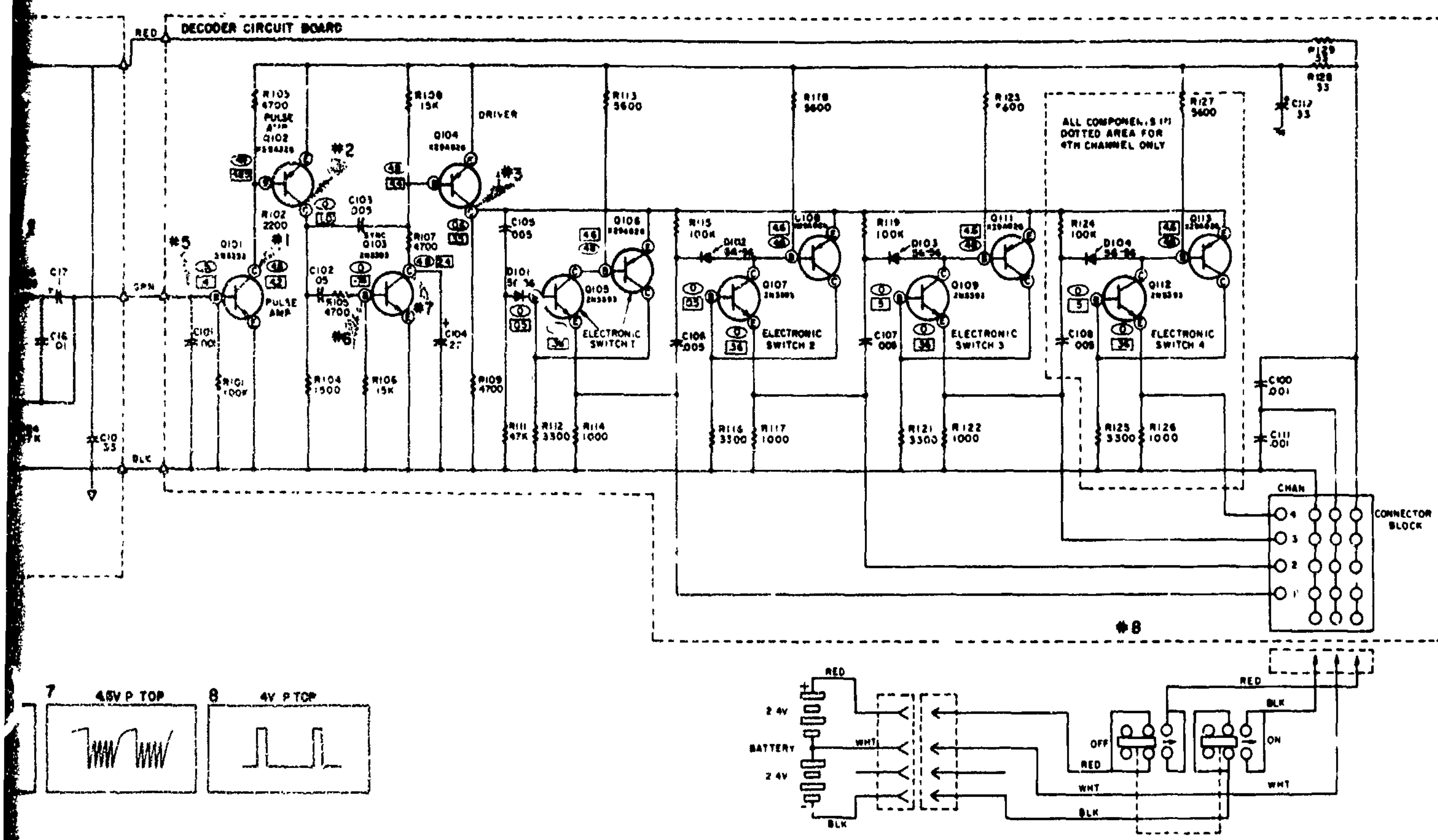


Figure 3-4. Receiver and



-4. Receiver and Decoder Circuits

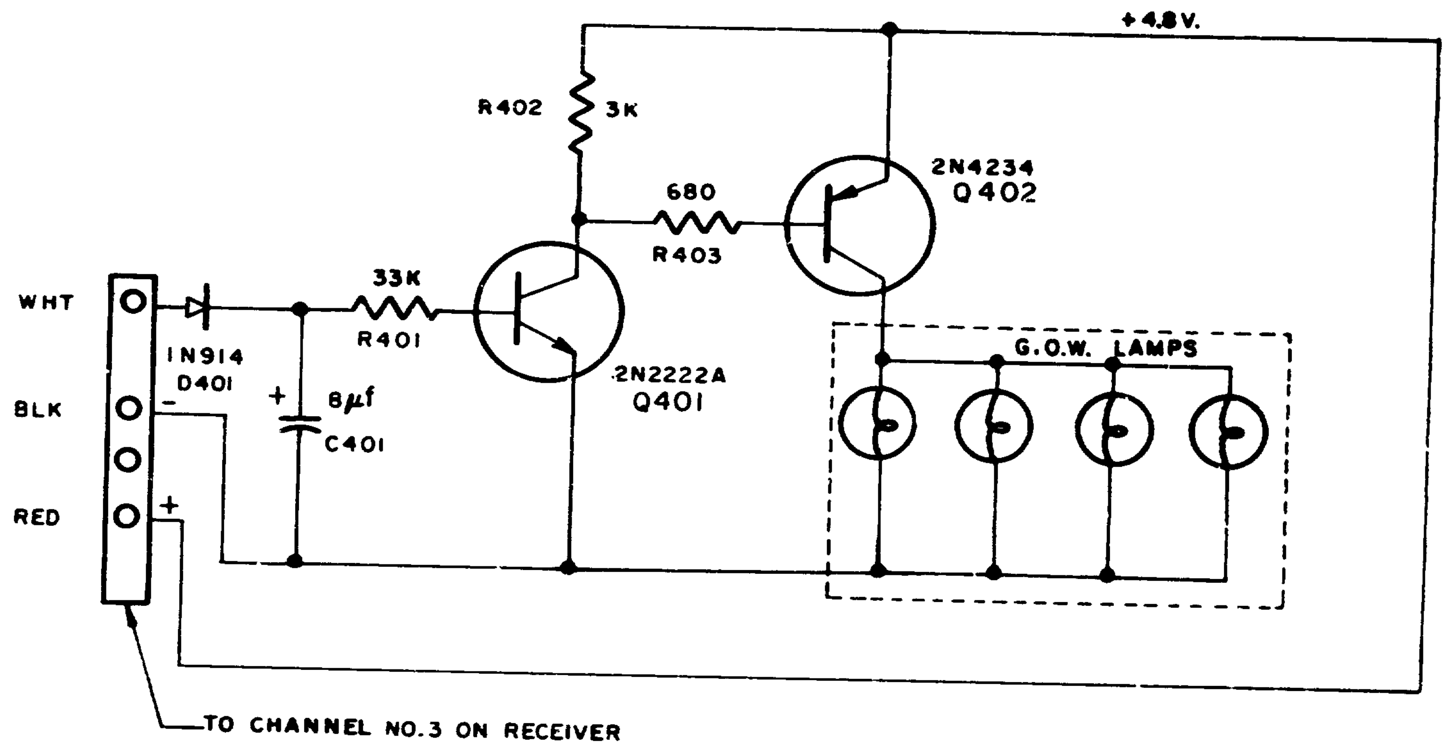


Figure 3-5. Lamp Driving Circuit

0-99 Parts mounted on the receiver circuit board
100-199 Parts mounted on the decoder circuit board
400-499 Parts mounted on the lamp driver circuit board.

The receiver circuit board contains a conventional crystal-controlled superheterodyne receiver with a power detector and an integrator circuit. The decoder circuit board contains a pulse amplifier, sync and driver circuits, and electronic switches.

3.2.1 RECEIVER CIRCUIT BOARD

The transmitted RF signal is picked up by the antenna and fed to the tuned circuit of T1 and C1. T1 and C1 are tuned to the transmitted signal frequency, and their values are selected for each band of frequencies.

From the secondary of T1, the signal is coupled to the base of RF amplifier Q1. The amplified signal from Q1 is applied to the tuned circuit of C4 and T2, which are also tuned to the transmitted signal frequency. T2 is tapped to provide an impedance match to the collector of Q1. From the secondary of T2, the signal is coupled to the emitter of autodyne converter Q2.

Regenerative feedback through the receiver crystal causes the autodyne converter circuit to oscillate. This will be at the crystal's fundamental frequency on the 27 Mhz band. The input signal and oscillator signal beat together in transistor Q2 to produce a 453 kHz difference signal that is passed through coil L1 and resistor R8 to the first ceramic (IF) filter, CF1. Capacitor C7 tunes with L1, near the crystal oscillator frequency.

The ceramic filters are made of an input and output filter. As the IF signal is applied to the input, it resonates at the IF frequency and passes the vibrations to the output, causing it to resonate at the same frequency. The ceramic filters will resonate at and pass only the frequency to which they are tuned, in this case the 453 kHz IF frequency.

The IF signal is coupled through CF1, CF2, CF3, and resistor R9 to the base of the first IF amplifier, Q3. The amplified IF signal from Q3

is further amplified by the second IF transistor, Q4, and coupled through capacitor C12 to the base of the power detector, Q5. Diode D1 is forward biased by resistor R15 so that about .5 volt is applied to the base of Q5 through L2, which will hold Q5 at cutoff. Since Q5 requires about .6 volt at its base to conduct, the additional voltage is supplied by the positive portion of the IF signal. Thus, transistor Q5 conducts only on the positive peaks of the IF signal.

When receiving an IF signal, Q5 is conducting. Then when a transmitted pulse is received, which temporarily stops the RF carrier, there is no IF signal to make Q5 conduct. Therefore, Q5 stops conducting and its collector voltage rises. This then produces a positive pulse from Q5 that is equivalent to the pulse in the Transmitter.

Capacitor C15 bypasses the IF frequency to ground and leaves a train of audio frequency pulses that are coupled through D2, R23, and C17 to the base of the pulse amplifier, Q101, on the decoder circuit board. Diode D2 and resistors R22 and R24 eliminate noise pulses under strong signal conditions, and integrator network resistor R23 and capacitor C16 prevent noise from interfering under weak signal conditions.

An automatic gain control (AGC) circuit that consists of resistors R17, R13, R3, and R1 with capacitor C9, feeds back part of the Q5 collector voltage to the base circuits of transistors Q1 and Q3. The stronger the received signal, the more transistor Q5 conducts, and lowers the voltage at its collector. This voltage is applied through R17, R13, and R3 to reduce the gain of Q1 and Q3. This AGC action prevents the IF amplifier and detector circuits from overloading and producing improper pulses when strong signals are received.

The output signal from the Receiver is a series of positive pulses that are spaced like the modulation pulses of the Transmitter. These signal pulses are coupled to the decoder circuit, which is described next.

3.2.2 DECODER CIRCUIT BOARD

Pulse amplifier transistors Q101 and Q102 further increases the amplitude of the pulses from Q5 on the receiver circuit board. Q101 and Q102 are normally cut off until the pulses reach a high enough amplitude to turn them on. This provides further noise immunity and produces clear sharp pulses at the collector of Q102.

The signal pulses from the collector of Q102 are coupled through C102 and R105 to the base of sync transistor Q103 and through C103 to the base of driver transistor Q104. Transistor Q104 is used to supply voltage to transistors Q106, Q108, and Q111. Q104 is normally cut off, which removes the voltage from Q106, Q108, and Q111. Q103 is also normally cut off, but conducts during each signal pulse from Q102. This controls the charge and discharge of capacitor C104 which controls Q104 during the sync pause time.

When Q103 is cut off during the sync pause time, capacitor C104 begins to charge through resistors R108 and R107 and the base emitter junction of Q104. The resulting voltage drop across R108 holds Q104 on until C104 becomes charged. When C104 becomes charged, Q104 returns to its normally cutoff condition.

Transistor Q103 conducts during each positive pulse it receives from Q102 and discharges capacitor C104. The four pulses of each train occur in such rapid succession that C104 cannot obtain a charge sufficient enough to turn Q104 off. However, during the sync pause time, Q103 is cut off long enough to permit C104 to charge up to the voltage which stops Q104 from conducting.

The first pulse following the sync pause turns on Q103, which discharges capacitor C104 and allows Q104 to conduct again. During the time that Q103 holds Q104 on, pulses are coupled from A102 through C103 to the base of Q104. These positive pulses turn Q104 off momentarily, which interrupts the emitter voltage on Q106, Q108 and Q111 for an instant.

Transistors Q105 and Q106 form an electronic switch. This switch can be turned on by applying a signal to the base of either transistor.

The following pairs of transistors, Q107 and Q108, and Q109 and Q111 also form switches that operate in the same manner. Each switch will remain on until Q104 turns off and removes the operating voltage from the switch.

The positive pulse from Q104 (through C105 and D101) turns on Q105. Q105 conducts, which makes the base of Q106 negative. This causes Q106 to conduct and places a positive voltage at the base of Q105 until Q104 turns off and removes the necessary operating voltage from the electronic switch. The switch will not turn on again until Q105 receives a positive voltage at its base. The electronic switching system operates in the following manner. See Figure 3-6.

The sync pause time of the voltage waveform (shown in waveform A) stops all electronic switches from conducting. The positive-going portion of the pulse (marked 0 in the waveforms), which is applied to all switches, prepare them to conduct. At the same time, the first portion of the pulse is differentiated by C105 and R111 and appears as the positive spike in waveform B. This spike turns on switch #1.

The negative spike marked "1" in waveform A is then applied to the emitter of Q106 and switch #1 is turned off. Th negative spike, 1, in waveform B only further insures the turnoff of the switch. The time that switch #1 was on is shown as 0 to 1 in waveform c.

As switch #1 is turned off, the negative-going trailing edge of the pulse in waveform C is coupled through C106 and D102 and turns on switch #2, as the emitter of Q108 is, by this time, positive again. Negative spike number 2 (in waveform A) then turns off switch number 2. As waveform D shows, switch #2 remains on for the time between 1 and 2 of waveform A.

The output from switch #2 then turns on switch #3, which is then turned off by negative spike #3 of waveform A. The sync pause time then

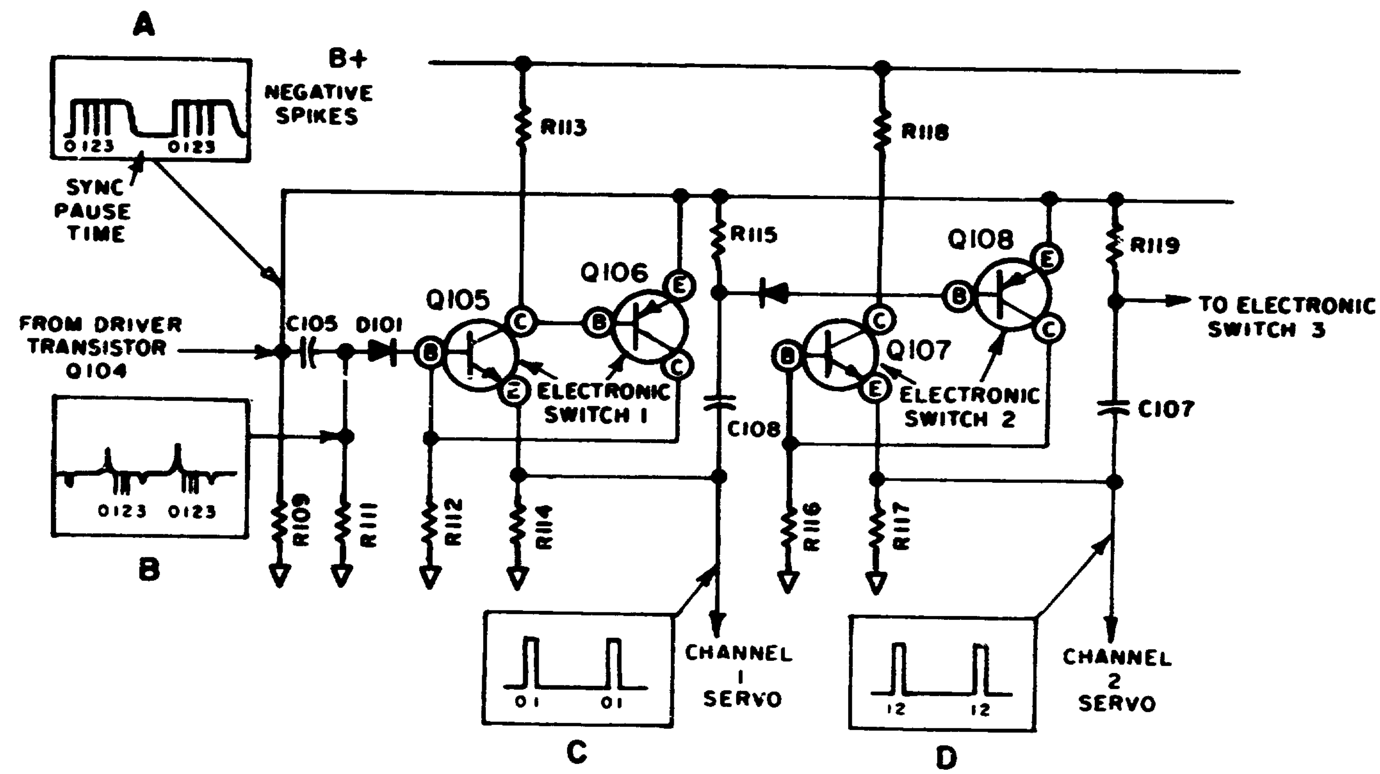


Figure 3.6. Electronic Switching System

allows the differentiating capacitor C104 to discharge and the process starts again with switch #1 at time 0.

The output current from switch #3 consists of pulses 1 to 2 milliseconds wide repeated 62.5 times per second and controlled by the lever on the right side of the transmitter case. These pulses are applied to the input of the lamp driving circuit.

3.2.3 LAMP DRIVING CIRCUIT

The pulses from the third channel of the receiver decoder are applied to the input of the driver circuit (Figure 3-5). Capacitor C401 integrates these pulses. When its charge has built up to nearly the peak value of the pulses (4 volts) transistor Q401 conducts heavily, and its collector saturates. When Q401 saturates, the base current of Q402 is a maximum and has a value of about 6.5 ma. This high value of base current causes the collector of Q402 to saturate also. When this occurs, approximately 4.6 volts are applied across the grain-of-wheat lamps.

When the output of the third channel of the decoder drops to zero (no i.f. signal being received), the charge on C401 is drained off through R401 and the base-emitter circuit of Q401 in approximately one second, and the IR lights are extinguished. The one second delay is slightly variable by varying the channel three potentiometers R12 and R204 in the transmitter.

3.2.4 RECEIVER POWER SUPPLY

The battery pack for the receiver supplies the receiver circuit, the decoder circuit and the lamp driver circuit. This battery pack is charged together with the transmitter battery from the single charger unit provided for this purpose.

3.3 Battery Charging

The recommended way to charge the transmitter and receiver batteries is to use the Charger and charge the batteries from 14 to 24 hours. (More than 24 hours will not add to the battery charge.) The transmitter and receiver batteries must be charged at the same time or the charging circuit will not work. However, if the receiver battery is charged on a separate charger, charge it at a rate of 50 mA for 14 hours.

Note the rounded end of the battery connector on the charging cable, this is the end to be connected to the transmitter. Make sure the Power switch is OFF and LOCKED. Connect the charging cable to the transmitter. Connect the rectangular connector end of the charging cable to the Receiver Battery which has been removed from the receiver assembly.

Note: The batteries will only charge when the slide switch of the Transmitter is in the OFF position.

If the meter in the Transmitter does not indicate when the charging cable is plugged into an AC outlet in the next step, unplug the cable right away and check the charging cable wiring. Plug the line cord end of the charging cable into a 120 VAC 60 Hz outlet. The meter should read approximately half scale (higher for a fully discharged battery and lower for a fully charged battery).

4. TESTS

Tests of the system were made in both the laboratory and in the field.

4.1 Laboratory Tests

4.1.1 TEMPERATURE

Temperature tests were made to ensure operation over a reasonable outdoor environment. The receiver was put into a temperature chamber and operated for 2 hours at 0 and 100°F. No malfunction or change in operation was noted.

4.1.2 CURRENT DRAIN

The receiving system draws approximately 4.5 milliamperes when no signal is being received and 260 milliamperes during signal reception with battery pack fully charged (5.4 volts). In four hours of receiver on without triggering the lights, battery voltage dropped 0.2 volts. With light on continuously, battery voltage dropped to 3.2 volts in 1.5 hours. System was still operating but lights were dim.

4.1.3 VISIBLE LIGHT OUTPUT

No visible light was observed emanating from the unit at 1 meter in a dark adapted environment.

4.2 Outdoor Tests

The system was operated outdoors (60°F) over a grassy and sidewalk area. Maximum range achieved was approximately 190 meters. Attempts to obtain even one additional meter of range were not successful. Since the receiver was equipped with the 18.5 inch whip antenna instead of a 36 inch antenna recommended by the manufacturer, the attempt was made to improve the match between the whip antenna and the receiver input circuit.

The aluminum housing for the receiver and lamp assembly was grounded to the common ground of the receiver and the antenna lead was connected to the top of the input coil. In order to resonate the input circuit, it was necessary to change the input resonating capacitor from 47 pf to 30 pp. These changes reduced range to nearly 100 meters, and the original configuration was restored.

After these unsuccessful trials, the antenna lead-in wire was re-arranged to that it entered a separate hole in the housing which was located as close as practical to the receiver input coil. The range measured was then 330 meters.

As a final assembly step, the antenna lead-in was rouzed along the harness and under the receiving housing so as to enter underneath it. A final range check was made outdoors. Weather conditions were moderate snowfalling and temperature approximately 35°F. The range obtained was 250 meters.

5. CONCLUSIONS AND RECOMMENDATIONS

The radio controlled IR indicator light met all of the performance requirements in the laboratory and outdoor tests at the contractor's plant. It should, therefore, be adequate for an evaluation of the usefulness of the system in field tests.

The arrangement of placing the light assembly on the top of the receiver-battery housing was an expedient that allowed the light to be about 3 inches above the dog harness. The optimum height of this assembly above the harness might be determined from field evaluation. The light assembly could be mounted on the dog harness directly with only a minor modification. The receiver-battery housing and antenna should be positioned close together so as to keep the antenna lead-in short. Range is adversely affected by lengthening this lead-in. Also, the housing is "floating" electrically and no attempt should be made to electrically bond the metal components.

Reception is coded so as to require access by compatible equipment. Thus, no false signalling should be expected from noise or other general RF fields. However, companion transmitters operating on the same frequency (model airplane R.C) could cause the receiver to trigger the lamp circuit if they are within range.

APPENDIX A

TRANSMITTER SPECIFICATIONS

RF Carrier Frequency	27.195 Mhz
Frequency Stability	Within ± .005%
Temperature Range	0 to 160 degrees F.
RF Output Circuit	Pi network
RF Input Power	500 mW
Modulation	ON-OFF carrier keying
Approximate Current Drain . .	100 mA
Controls	Three channels; ON/OFF switch
Power Supply	Internal 9.6V, 500 mA hours, nickel-cadmium battery. Rechargeable simultaneously with receiver battery at 50 mA from external charger
Dimensions	9-1/2" high x 3-11/16" wide x 2-1/4" deep
Net Weight, with battery . . .	2 lbs.

APPENDIX B

RECEIVING SYSTEM SPECIFICATIONS

RF Carrier Frequency	27.195 Mhz
Frequency Stability	.003%
Temperature Range	0 to 160 degrees F.
Sensitivity	5 µV or better
Selectivity	6 dB down at ± 4 kHz 30 dB down at ± 9 kHz
Approximate Current Drain . . .	4.5 ma (no signal), 260 ma (with signal)
Intermediate Frequency	453 Khz
Power Supply	4.8V; Battery Pack GDA-405-3
Controls	ON-OFF switch
Weight	13 oz. (less dog harness)
Complete Receiving System Weight .	26 oz. (including harness)
Dimensions	3 1/8 x 3 1/16 x 3 5/32 overall including lamp housing. See also Figures B-1, B-2 and B-3.

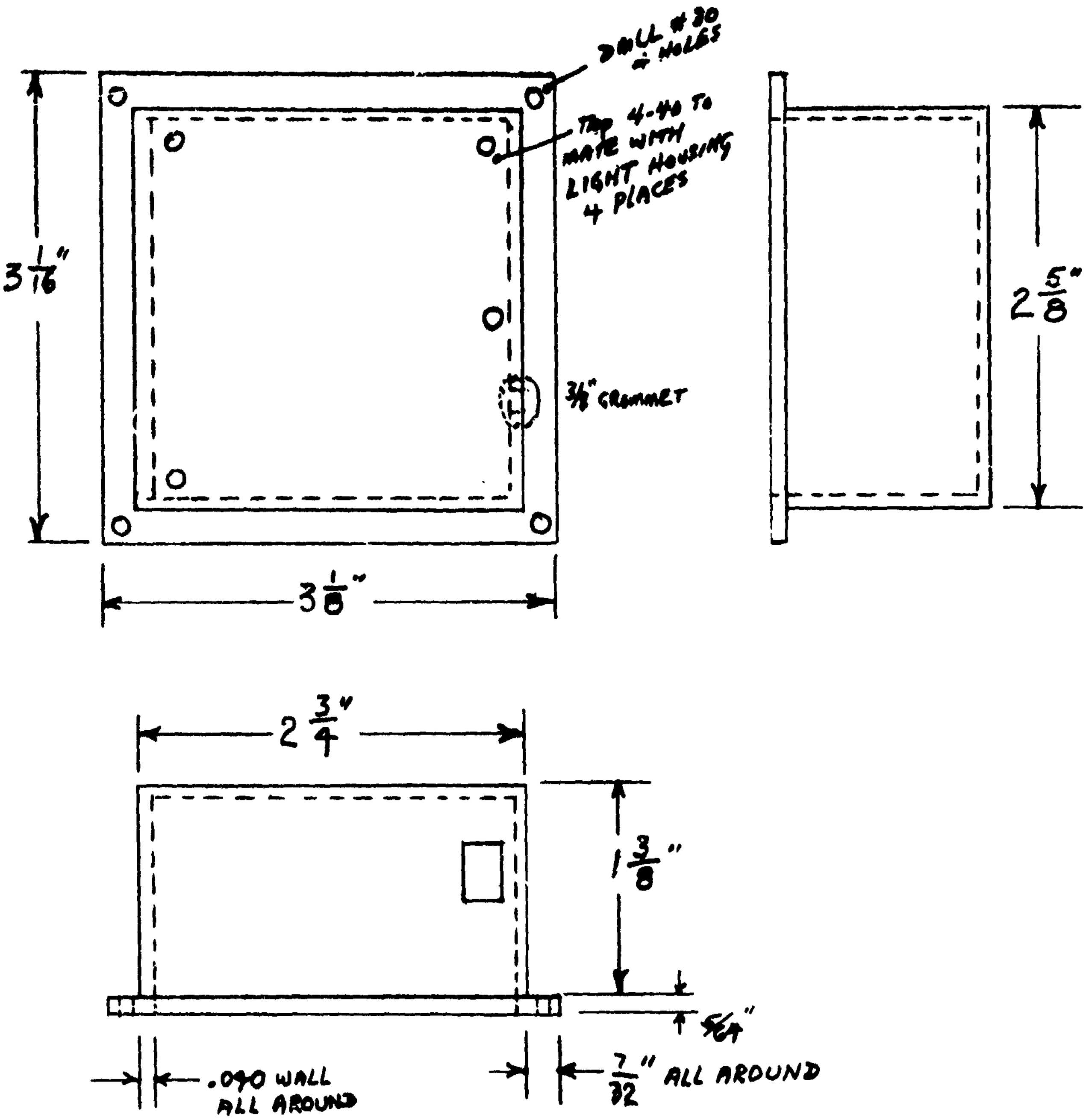


Figure B-1. Receiver Housing (Aluminum)

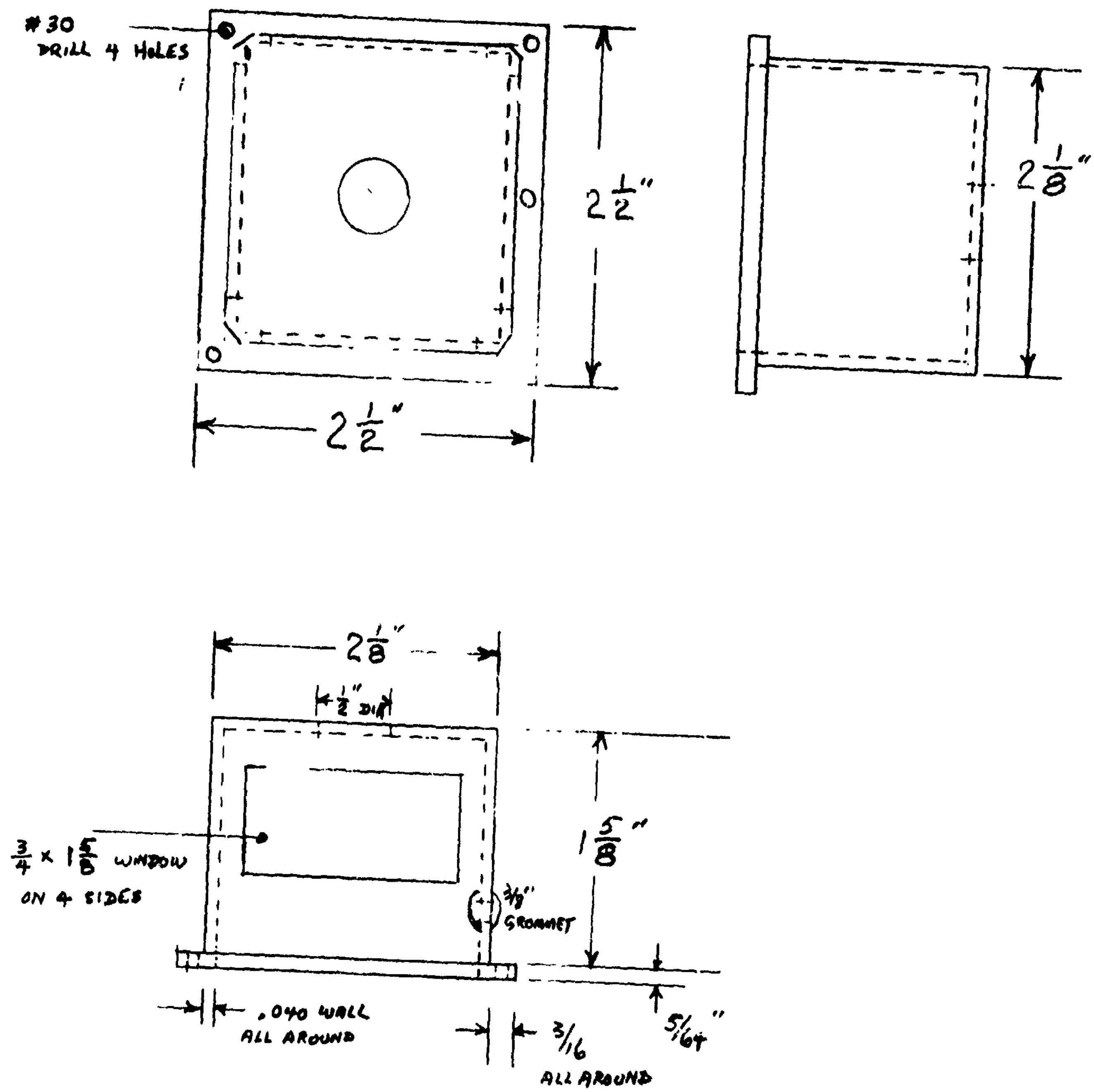


Figure B-2. Light Housing (Aluminum)

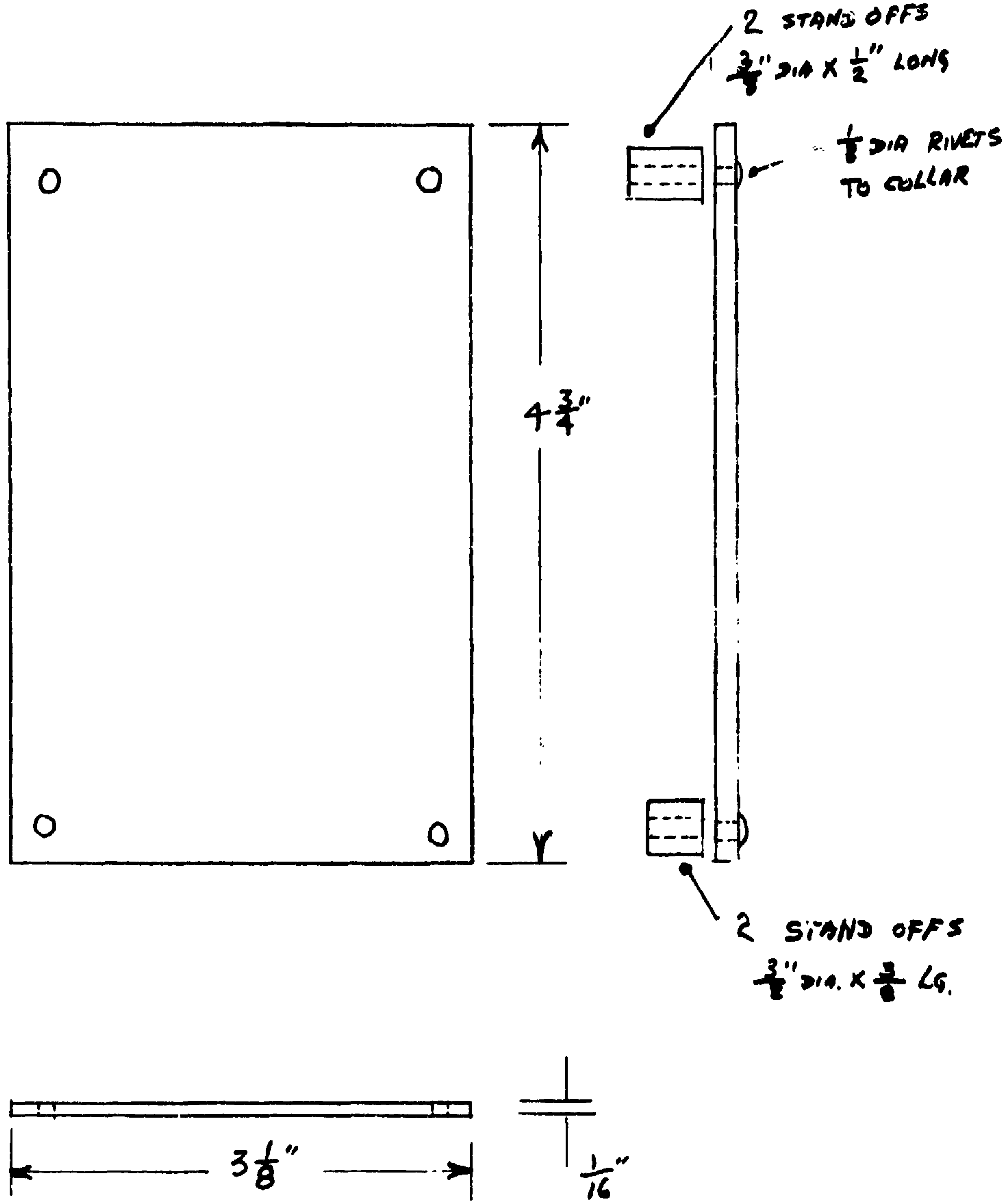


Figure B-3. Mounting Plate (Aluminum)

APPENDIX C - PARTS LIST

TRANSMITTER

Encoder Circuit Board

Schematic Reference	Description
C1	.1 mfd mylar
C2	.001 mfd disc
C3	.001 mfd disc
C4	.1 mfd mylar
C5	.005 mfd disc
C6	.022 mfd mylar
C7	.001 mfd disc
C8	.005 mfd disc
C9	.001 mfd disc
C11	.022 mfd mylar
C12	.001 mfd disc
C13	.005 mfd disc
C14	.001 mfd disc
C15	.022 mfd mylar
C16	.001 mfd disc
C17	.001 mfd disc
C18	.005 mfd disc
C23	.001 mfd disc
C24	.001 mfd disc
C25	50 mfd electrolytic
C26	.022 mfd mylar
C27	.001 mfd disc
C28	.001 mfd disc
C29	.1 mfd mylar
C33	.01 mfd mylar
D1	GE-S160
D2	GE-S160
D3	GE-S160
D4	GE-S160
D5	GE-S160
D6	GE-S160

Schematic Reference	Description	
R1	4700	1/4W
R2	111K	1%
R3	111K	1%
R4	47K	1/4W
R5	200K	trimmer
R6	100K	1/4W
R7	47K	1/4W
R8	200K	trimmer
R9	100K	1/4W
R11	47K	1/4W
R12	200K	trimmer
R13	100K	1/4W
R14	47K	1/4W
R15	4700	1/4W
R19	47K	1/4W
R21	1000	1/4W
R22	2200	1/4W
R23	4700	1/4W
R24	27K	1/4W
Q1	2N3393	
Q2	2N3392	
Q3	2N5232A	
Q4	2N5232A	
Q5	2N5232A	
Q7	X29A829	
Q8	X29A829	
Q9	X29A829	

RF Circuit Board

Schematic Reference	Description
C101	.01 mfd
C102	7.5 pf
C103	56 pf
C104	62 pf
C105	470 pf
C106	75 pf
C111	.02 mfd
D101	2N191
R101	4700 1/4W
R102	4700 1/4W

Schematic Reference	Description
R103	150 1/4W
R104	100 1/4W
R105	47K 1/4W
L101	(.73μh) variable core
L102	15μh
L103	2.2μh
Q101	2N2369
Q102	2N3641
T101	Variable core
XTAL	Crystal 27.195 Mhz

Case Mounted

C201	100 pf
R202	5000 potentiometer
R203	5000 potentiometer
R204	5000 potentiometer
R206	1.5 Ω 1/2 w
S1	DPDT switch
S2	Push-button switch (normally open)

Battery Charger

D301	1N4002
T301	low voltage transformer (12v)

APPENDIX C - PARTS LIST (cont'd)

RECEIVER

Receiver Circuit Board

Schematic Reference	Description	
C1	47 pf disc	
C2	.001 mfd disc	
C3	.047 mfd tantalum	
C4	47 pf disc	
C5	.01 mfd mylar	
C6	75 pf disc	
C7	47 pf disc	
C8	33 mfd tantalum	
C9	2.2 mfd tantalum	
C11	.033 mfd mylar	
C12	180 pf disc	
C13	.047 mfd tantalum	
C14	.0033 mfd mylar	
C15	.047 mfd tantalum	
C16	.01 mfd mylar	
C17	1 mfd tantalum	
C18	33 mfd tantalum	
D1	1N4149	
D2	1N4149	
D3	GE-S160	
Q1	SE5055	
Q2	16G2349	
Q3	2N3393	
Q4	X29A826	
Q5	2N5232A	
R1	33K	1/4W
R2	1000	1/4W
R3	18K	1/4W
R4	6800	1/4W
R5	820	1/4W
R6	5600	1/4W
R7	2700	1/4W
R8	100	1/4W
R9	1000	1/4W
R11	2200	1/4W
R12	2200	1/4W

Schematic Reference	Description	
R13	22K	22K
R14	2200	1/4W
R15	15K	1/4W
R17	10K	1/4W
R18	100	1/4W
R19	1000	1/4W
R21	22K	1/4W
R22	15K	1/4W
R23	5600	1/4W
R24	27K	1/4W
L1	2.2μh	
L2	1mh	
T1	4-lead variable trans-former	
T2	5-lead variable trans-former	
CF1	Ceramic 1F Filter	
CF2	Ceramic 1F Filter	
CF3	Ceramic 1F Filter	
XTAL	Crystal 26.742 Mhz	

Decoder Circuit Board

Schematic Reference	Description
C101	.001 mfd disc
C102	.05 mfd disc
C103	.005 mfd disc
C104	.22 mfd tantalum
C105	.005 mfd disc
C106	.005 mfd disc
C107	.005 mfd disc
C109	.001 mfd disc
C111	.001 mfd disc
C112	33 mfd tantalum
D101	1N4149
D102	1N4149
D103	1N4149
Q101	2N3393
Q102	X29A826
Q103	2N3393
Q104	X29A826
Q105	2N3393
Q106	X29A826
Q107	2N3393
Q108	X29A826
Q109	2N3393
Q111	X29A826

Schematic Reference	Description	
R101	100K	1/4W
R102	2200	1/4W
R103	4700	1/4W
R104	1500	1/4W
R105	4700	1/4W
R106	15K	1/4W
R107	4700	1/4W
R108	15K	1/4W
R109	4700	1/4W
R111	47K	1/4W
R112	3300	1/4W
R113	5600	1/4W
R114	1000	1/4W
R115	100K	1/4W
R116	3300	1/4W
R117	1000	1/4W
R118	5600	1/4W
R119	100K	1/4W
R121	3300	1/4W
R122	1000	1/4W
R123	5600	1/4W
R128	33	1/4W
R129	33	1/4W

Lamp Driving Circuit

C401	8mfd	Electrolytic
D401	1N914	
R401	33K	1/2W
R402	3000	1/2W
R403	680	1/2W
Q401	2N2222A	
Q402	2N4234	